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ABSTRACT

A project was devised to extend the applicability of a previously developed computer-assisted instruction (CAI) course in instrumental musicianship (see ED 035 314), and to assess its effects through the development and implementation of criterion referenced measures. Twenty-five intermediate level students of treble clef wind instruments participated as subjects in the evaluation phase of the project: all students were given a listening pretest involving aural and aural-visual discrimination and a performance pretest; attended a CAI lab twice weekly which included online listening and coordinated offline practice; and completed posttests which were the same measures administered previously as pretests. Group gains in both listening and performance were significant and dramatic; since the students had been playing these instruments for five or more years, it is presumed that the results can be attributed to the experimental treatment even without comparison with a control group. (SH)

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FINAL REPORT

OE Project No.: 2-C-001
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Ned C. Deihl
Principal Investigator

Ray H. Zeigler
Associate Investigator

EVALUATION OF COMPUTER-ASSISTED INSTRUCTION IN INSTRUMENTAL MUSICIANSHIP

August 15, 1972

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CHAPTER I

INTRODUCTION AND OVERVIEW

Introduction

This project was a sequel to the study by Deihl and Radocy, "Development and Evaluation of Computer-Assisted Instruction in Instrumental Music" (USOE Project No. 7-0760), completed in 1969. In the first study computer-assisted instruction (CAI) in instrumental musicianship and a coordinated performance practice program were developed and formatively evaluated through field testing and extensive revision. Aural models for the original program were limited to clarinet and the subjects in the pilot sample were restricted to clarinet students. The feasibility of the program led to the present study.

Purpose of the Study

The purpose of the present project was to extend the applicability of the course developed in USOE Project 7-0760 by diversifying the CAI aural models and off-line performance to other treble clef woodwind and brass instruments and to make a summative evaluation of the program through the development and implementation of criterion-referenced measures.

Background

In developing the original program the investigator explored the feasibility of new technology, computer-assisted instruction, in instrumental musicianship, particularly ear-training or aural-visual discrimination for intermediate level instrumentalists in the areas of phrasing, articulation, and rhythm. The original USOE study was confined to clarinet models and piloted by fourteen intermediate level clarinetists; the aural concepts involved, however, are generally basic to all wind instrumentalists. Although the technical means of achieving certain interpretations on various instruments may differ, the aural result should be generally the same.

An off-line practice program coordinated with the CAI program was also developed and piloted by the fourteen clarinetists. Generally, a dual program

was developed: 1) an aural program on-line (via CAI) emphasizing aural-visual discrimination, and 2) a related playing-recording program off-line (without computers) using specially modified tape recorders programed with pre-recorded models. Some playing-recording was also done on-line, although this time-consuming practice (particularly if students had technical difficulty) did not seem economically feasible.

The program was based on the rationale that aural concepts and performance achievement are related and this assumption of the dual approach was supported by correlation data reported in the present study.

The IBM 1500 Instructional System at The Pennsylvania State University Computer Assisted Instruction Laboratory, employed in this study, cannot monitor or process musical input, although this eventually may be a possibility in computer-assisted instruction. The present system can, however, efficiently and flexibly coordinate presentation of aural-visual stimuli, process student light pen responses, branch students to various options and remediation according to programed criteria, and print out detailed student records.

The reader seriously interested in the present study is referred to the original report, ERIC No. ED 035-314.

CHAPTER II

PROCEDURES

Review and Debugging of 10,000 Program Statements

Preparation began with a review of the existent CAI instrumental program developed under USOE Contract No. OEG-1-7-070760-5-316. The complete program of over 10,000 Coursewriter statements was "debugged," a procedure requiring one to "take" the course, including all alternatives and branches. This process uncovered some programing errors which were probably due to revisions made in the previous program.

Review and Expansion of the Performance (Off-line) Program

The original project used two IBM prototype instant-comparison tape recorders in the off-line program. Since only two of the experimental machines were available, the increased size of the present sample prevented inclusion of this part of the program. Instead, additional samples of music were found for related off-line practice.

Considerable searching was necessary to expand the program from clarinet only to treble clef wind instruments. Off-line practice books contained 192 musical excerpts for each instrument. The selected music was limited to copyright-free domain, and in some cases original items were composed. Of necessity, many of the excerpts were transposed to accommodate the ranges of the instruments. While some of the items were taken from the on-line program, most were selected to augment on-line examples. At attempt was made to keep the technical hurdles minimal so that a performer's limited technique would not hinder attainment of the performance objectives in articulation, phrasing, and rhythm.

After the identification and selection of items were completed, each example was transferred in legible manuscript to a 5 x 8-inch card. The cards were then photocopied so that five woodwind and three brass books were available. The practice materials were segmented into units which were coordinated with the on-line program.

CAI Audio Assembly

The audio portion of the previous program, formerly clarinet only, was re-recorded in its entirety. The present program contains 255 musical excerpts. In addition to clarinet, melodic examples were recorded on flute, saxophone, trumpet, and horn. Even though musical excerpts were identical to the ones in the former program, a more versatile sound track was produced by diversifying the instrumentation. Examples were categorized and assigned according to range and idiomatic suitability. The melodies were recorded by members of The Pennsylvania State University performing organizations. In addition, the verbal messages were rerecorded. These messages, in many cases, were readings of messages shown on the CRT so that the student could both see and hear important instructional information.

An Ampex Model AG500 tape recorder was used with an Electro-Voice 676 microphone. While the verbal and musical messages were recorded on the left channel, a 400 Hz tone was applied to the right channel for later use in audio assembly. After the master tape was recorded at 7.5 inches per second (ips), it was prepared (assembled) for student use via the IBM 1500 Instructional System and a 1506 audio unit. The student cartridges were recorded at 1.875 ips, the only speed available on the 1506 unit. Although white noise, or tape hiss, was noticeable, sound reproduction was judged satisfactory.

The audio assembly process is described in detail in the original report. For audio assembly of this program student cartridges were made directly from the source masters. This eliminated one generation in the duplicating process resulting in substantial improvement of audio quality.

Preparation of Image Reels

Hard-copy images of musical notation were rephotographed using high-contrast 35mm film. The resulting double-frame 2 x 2-inch slides were then photographed on 16mm film, the size used by the IBM 1512 image projector. An address track, a series of symbols applied to the edge of the film and used by the 1500 system to locate images, was added at the processing laboratory.

Some difficulty was experienced in transferring from the slides to the 16mm film. Because the laboratory which processes the film and adds the address

track no longer had facilities for developing black and white film, the slides were copied on color stock. A "blossoming" resulted which seriously affected the resolution of the final image. The problem was solved by shooting the slides on a pre-addressed black and white film, sending the film to another laboratory which processed black and white, and then returning the film to the first laboratory for duplication. The resulting images were highly satisfactory.

After the new audio and images were completed, the entire program was once again "debugged" to assure complete syncronization of all facets. Some audio and image symbols had been inadvertantly changed, but were corrected before students used the program.

Program Objectives

The purpose of the research was to assess the effectiveness of the revised CAI course in instrumental musicianship and the coordinated off-line program through the development and implementation of criterion-referenced measures. The measures served as pre- and posttests for the eight-week program administered to the sample of twenty-five instrumentalists. The following objectives served as the relevant domain for the test items:

I. Articulation

The student will:

1. identify eight aurally presented basic articulation patterns;
2. identify three aurally presented articulation styles (staccato, unmarked, and portato);
3. detect aural-visual discrepancies in articulation pattern and style;
4. compare aurally and visually two performances differing only in the correctness of articulation and select the better example.

Performance

The student will:

1. record a given passage with correct articulation pattern or style.

II. Phrasing

The student will:

1. identify aurally and/or visually the end of a phrase;
2. detect aural-visual discrepancies (implicit and explicit) in crescendo and diminuendo nuances;
3. detect clipped or abruptly terminated phrase endings;

4. detect a breathing gap interrupting a phrase;
5. identify aurally-visually the peak note or melodic climax of a phrase;
6. compare aurally-visually two performances differing only in the phrasing and choose the better example.

Performance

The student will:

1. record a given passage with correct phrasing (breathing at proper point; crescendo and diminuendo nuance).

III. Rhythm

The student will:

1. detect aural-visual discrepancies in rhythm;
2. determine possible meter signatures for a recorded excerpt;
3. detect the visually presented measure which has an incorrect amount of time values according to time meter;
4. discriminate correct mathematical relationship between sixteenth, eighth, quarter, half, and whole notes.

Performance

The student will:

1. record a given passage with correct rhythm.

Development of the Test of Instrumental Musicianship (Listening Test)

A criterion-referenced test was constructed to reflect the CAI program objectives. This test was not computerized. Since all but four of the twenty-six items involved listening, the test is herein referred to as the Listening Test. Those four items not involving listening consisted of mathematical rhythmic and metric relationships.

The majority of test items involved aural-visual discrimination. The test was of sufficient length to give reliability yet not cause fatigue or lapses of attention. Musical examples were notated on 5 x 8-inch cards, copied, and stapled into booklets. Each item was numbered to coordinate with the answer booklet.

The music for the aural items was performed by the same instrumentalists who recorded the on-line excerpts. Instruments included flute, clarinet, saxophone, trumpet and horn.

Development of the Performance Test

The performance test, like the performance program, was developed from a pool of musical excerpts chosen for their appropriateness in exemplifying the performance objectives. All students played the same melodic excerpts which, if necessary, were transposed into keys keeping ranges within comfortable limits.

The final test contained nine items written in legible manuscript on 5 x 8-inch cards. Musical examples used for the listening and performance programs and tests were either in the public domain or composed specifically for the tests.

Piloting the Listening Test

The listening test was piloted in a nearby school district, with students comparable to the target population in order to evaluate the items. As a result, the test was considerably revised to eliminate items which were found to be extremely easy or difficult.

Piloting of the Performance Test

The performance test was also piloted with eighth and ninth-grade instrumentalists from the same school district as above. Piloting was done with treble clef wind instruments, the type for which the program was designed. As in the performance program, items of minimal technical difficulty were sought. The present nine-item performance test resulted from the pilot study. Six of the nine items appeared in the performance program of 192 items.

Pretesting and Selection of Sample

Over forty intermediate-level instrumental music students in the State College Area Schools were individually auditioned and recorded to ascertain

level of entering behavior. It was necessary to eliminate those students who were below the minimal level of manipulative skill deemed necessary to accomplish the performance program.

The qualifying sample consisted of twenty-five students; all were junior high level except a few brass players in grades 10 and 11. There was a wide variation of proficiency within the group which included flute, clarinet, oboe, saxophone, trumpet, and treble clef baritone.

After selection was completed, the entire group was given the listening pretest. The text, involving aural and aural-visual discrimination, was administered twice so that the students could double-check their answers. (In a subsequent revision of the test for future use, each item will be immediately repeated.)

After the listening pretest, which was administered off-line, the subjects were given their student identification numbers and an on-line orientation. Orientation did not preview any of the music program; instead, mathematical games were used to acclimate the students to the system.

Program Implementation

Each student attended the CAI lab twice weekly. Most sessions were one hour in length, approximately thirty minutes on-line and thirty minutes off-line. Off-line practice was coordinated with the on-line listening so that the student was playing music directly related to the instructional material he had just covered. This coordination required careful record keeping in both a student log book and on a composite wall chart. Student on-line progress was printed out daily. The listing included the student number, the student's name, the last frame completed by the student when he signed off, and the total number of minutes on-line from the beginning of the program.

All responses made by the student at the CAI terminal were recorded and later retrieved by computer printout. This system capability allows for careful study of both the student's progress as well as effectiveness of program items.

Students were also informed of a system capability called the "comment routine." This allowed the student to temporarily terminate instruction for the purpose of recording a comment on the program. The student indicated to the

computer that he wished to comment. While he typed his comment, it was reproduced both on the cathode ray tube (CRT) and on paper at the proctor station. In addition, the comment was stored on the magnetic performance tapes and printed with the student records at the end of the course. A typical use of the routine was to cue the proctor of an unintentional wrong response caused by the light pen slipping on the glass CRT screen. After commenting, the student was automatically returned to the point at which he had left the program.

When absences and scheduling conflicts occurred, individually scheduled sessions were arranged. This sort of individualization is a strong feature of CAI, making such conflicts and absences relatively inconsequential.

Posttesting

The posttests were the same measures administered before the program. Students were individually administered the performance posttest as they individually finished the program. The listening measure was administered to small groups soon after they finished the program. In both cases, the sound equipment used was identical to that used for the pretest. As in the pretest, the listening test was administered twice so that the students could double-check answers.

Scoring of the Listening Test

Each of the twenty-six items in the listening test was assigned one point. No partial points were given; the items were scored as either right or wrong The percent correct was obtained by dividing the number of correct responses by twenty-six. In some cases the student responded on an answer sheet; in others he responded directly on the musical notation itself.

Judging the Performance Test

Each of the 450 pre- and posttest performance items was dubbed in random order on to a master tape for judging purposes. The four judges were not aware whether the item was a pre- or a posttest performance.

Rating scales were devised along with judging forms. The judges were informed of the objective for each item and provided with the notation of the musical excerpt. Before judging sessions of a particular excerpt (50 randomly ordered student performances) a few student examples were played to orient the judges to the excerpt, objective, and approximate range of proficiency of the students.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA

This chapter includes a presentation and analysis of data, a comparison of pre- and posttest scores in both listening and performance. It is organized into three sections: listening, performance, and on-line program data extracted from CAI student records.

Test of Instrumental Musicianship (Listening Test)

The Test of Instrumental Musicianship consisted of twenty-six items. (Since all but four of the 26 items involved listening, the test is also referred to herein as the Listening Test.) This measure involved aural and aural-visual discrimination in articulation, phrasing, and rhythm. A number of the musical examples used in the test were taken from the CAI (on-line) program containing 255 excerpts. A few were extracted from the off-line program which totaled 192 excerpts; still others were written expressly for the test. The same test was administered before and after the program, a span of about five or six weeks.

The dual program of listening and performing is based on the rationale that aural concepts of instrumental musicianship are related to instrumental performance. A Pearson Product-Moment correlation coefficient of .59 ($p < .002$) between listening and performance scores in this study supports that assumption.[1]

The *t* tests for related measures indicated that gains in scores from pretest to posttest were statistically significant beyond the .001 level of confidence (see Table 1).

The pretest scores, posttest scores, and gains for each student are shown in Table 2. These scores are arranged in rank order of posttest achievement.

Since the test is criterion-referenced, the posttest achievement is as important as the pre-post gains. A criterion level in a relatively untested

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[1]Since variance is necessary to calculate meaningful correlation, this correlation is based on pretest data. Criterion-referenced posttest scores are skewed too high to have sufficient distribution for correlation.

Table 1

Results of Listening Pretest-Posttest Comparison

Mean Percent Correct		S. D.	t
Pre	62.8%	15.85	
Post	92%	6.52	12.56*

*The pre-post difference is statistically significant with $p < .001$.

area is somewhat arbitrary, particularly since the measure itself may need further refinement. The investigator believed, however, that 85 percent correct was a reasonable goal for the age group involved. All but three of the twenty-five students in the sample achieved this criterion level and those three were close with scores of 81 percent. (One of those three pretested at 50 percent, the other two at 65.) Only one of the twenty-five subjects met the criterion on the pretest and that subject attained 100 percent of the posttest. Over half of the subjects achieved scores beyond 90 percent (see Table 3).

The test items reflect all of the program objectives. Data in Table 4 are based on the percent of students correctly answering the question or questions related to specific objectives. Five of the objectives were achieved by the entire sample while six of the objectives had a 90 percent mean score. Only four objective-related test items did not have a mean score of 90 percent. The most dramatic gain was on the third phrasing objective. Scores in this case rose from 12 percent on the pretest to 100 percent on the posttest. The least gain was on aural identification of meter. Practically no gain was evidenced on this, as measured by the present listening test.

Table 2

Student Scores on Listening Test
(Posttest Rank Order)

Student	Pretest	Posttest	Gain
F	58%	100%	42%
H	81	100	19
L	89	100	11
M	65	100	35
N	81	100	19
S	48	100	52
E	62	96	34
T	65	96	31
V	62	96	34
X	65	96	31
Y	69	96	27
D	58	92	34
O	62	92	30
R	73	92	19
C	77	89	12
A	34	89	55
J	69	89	20
K	65	89	24
Q	65	89	24
P	54	85	31
U	31	85	54
W	37	85	48
B	50	81	31
G	65	81	16
I	65	81	16
Means	62.8%	92.0%	30.0%

Table 3

Listening Posttest Scores
(Criterion: 85% Correct)

Percent Correct	Number of Students
100	6
96	5
92	3
89	5
85	3
81	3

Performance Test

The performance test consisted of nine musical excerpts, each chosen and scored for a particular emphasis. The nine items were a compilation of two phrasing items, two articulation items, two rhythm items, and three integrated items, i.e., items scored for a combination of areas, such as articulation and rhythm. Some of the nine items were extracted from the 192-item off-line program. A point system was devised for scoring each item, and four judges rated the 450 randomly-ordered, pre- and posttest recorded excerpts on tape.

Inter-judge reliability. Analysis of variance data were used to estimate inter-judge reliability of the judges on the performance measure. Data included scores of four judges on 450 excerpts. Reliability coefficient for the pretest was .93. (On the posttest performances, which had less variance, the reliability was .86). Agreement among judges was, therefore, extremely high.

Analysis of scores. The four judges' scores were converted to percentages and averaged for a mean score on each item. Using the *t* test for related measures, the group gains were statistically significant beyond the .001 confidence level (see Table 5).

Table 4

Mean Scores on Objective-Related Listening Test Items

Area	Objective-Related Test Items	Mean Percent Correct	
		Pretest	Posttest
I. Articulation	1. Aurally identify eight basic articulation patterns	79%	99%
	2. Aurally identify three articulation styles (staccato, unmarked, and portato).	60	84
	3. Detect aural-visual discrepancies in articulation pattern.	45	83
	4. Detect aural-visual discrepancies in articulation style.	66	90
	5. Aurally-visually compare two performances differing only in correctness of articulation and select the better example.	84	100
	Articulation: Grand Means	67%	91%
II. Phrasing	1. Aurally and/or visually identify the end of a phrase.	84%	100%
	2. Detect aural-visual discrepancies (implicit and explicit) in crescendo and diminuendo nuances.	80	96
	3. Detect clipped or abruptly terminated phrase endings.	12	100
	4. Detect a breathing gap interrupting a phrase.	52	100
	5. Aurally-visually identify the peak note or melodic climax of a phrase.	62	92

Table 4 (Continued)

Area		Objective-Related Test Items	Mean Percent Correct Pretest	Posttest
II.	Phrasing (Continued)	6. Aurally-visually compare two similar performances differing only in phrasing, and choose the better example.	44	98
		Phrasing: Grand Means	56%	98%
III.	Rhythm	1. Detect aural-visual discrepancies in rhythm.	38%	78%
		2. Aurally determine possible meter signatures for a recorded excerpt.	72	76
		3. Visually detect the measure which has an incorrect amount of time values according to time meter.	88	100
		4. Discriminate correct mathematical relationship between sixteenth, eighth, quarter, half, and whole notes.	75	93
		Rhythm: Grand Means	68%	87%

Table 5

Results of Performance Pretest-Posttest Comparison

Mean Percent Correct		S. D.	t
Pre	38.8%	16.11	
Post	94%	5.77	15.90%

*The pre-post difference is statistically significant with $p < .001$.

Table 6 lists pre- and posttest scores and gains for each student. Most remarkable gain was Student A who rose from 13 percent on the pretest to 99 percent on the posttest. (See also Table 7.) All but three of the twenty-five students exceeded the 90 percent level on the posttest. As with the listening test, a criterion level of 85 percent was deemed satisfactory in this study. Even the scores of the lowest three subjects were not far from criterion level with scores of 79 percent, 80 percent, and 83 percent.

Student mean scores on individual performance test items are shown in Table 8. Included is a task description, the area and objective for which the item was scored by the judges. All of the items, except the first phrasing item, had a mean of 90 percent or more on the posttest.

Table 9 (see Appendix) presents an analysis of student performance scores and mean gains on each item, grouped by areas. The largest gains were in the areas of phrasing and articulation, perhaps because the pretest rhythm scores were the highest of the three areas.

A comparison of each student's scores on listening and performance pretest and posttest are shown in Table 10 (see Appendix). The correlation of listening and performance scores, mentioned earlier, indicated at the $p < .002$ level of confidence that a significant relationship exists.

Table 6

Student Scores on Performance Test
(Arranged in Posttest Rank Order)

Student	Instrument	Pretest Score	Posttest Score	Gain
A	Clarinet	13%	99%	86%
H	Trumpet	42	99	57
N	Flute	59	99	40
Q	Trumpet	34	99	65
T	Trumpet	35	99	64
C	Trumpet	77	98	21
W	Tenor Sax	48	98	50
F	Trumpet	42	97	55
I	Flute	28	97	69
J	Clarinet	37	97	60
K	Flute	55	97	42
P	Alto Sax	22	97	75
S	Clarinet	26	97	71
D	Oboe	31	96	65
X	Clarinet	24	95	71
Y	Fr. Horn	41	94	53
U	Trumpet	20	93	73
G	Flute	43	92	49
L	Flute	70	91	21
M	Clarinet	25	91	66
O	Clarinet	23	91	68
R	Clarinet	55	91	36
V	Fr. Horn	24	83	59
E	Oboe	44	80	36
B	Baritone 𝄢	51	79	28
Means		38.8%	94.0%	55.2%

Table 7

Performance Posttest Scores
(Criterion: 85%)

Posttest Percent Correct	Number of Students
99%	5
98	2
97	6
96	1
95	1
94	1
93	1
92	1
91	4
83	1
80	1
79	1

Table 8

Mean Scores on Individual Performance Test Items

Item No.	Mean Score	Area:	Task
1	88%	Phrasing:	Crescendo and Diminuendo Nuance
2	95	Phrasing:	Crescendo and Diminuendo and Peak Note Stress
3	98	Articulation:	Pattern
4	95	Articulation:	Style
5	91	Rhythm:	Accuracy
6	98	Rhythm:	Accuracy
7	92	Integrated:	Articulation and Phrasing
8	93	Integrated:	Articulation and Phrasing
9	95	Integrated:	Articulation and Rhythm

Analysis of Listening and Performance Scores

In general, scores on the criterion-referenced posttests were most satisfactory. Least gains in the on-line listening program were made in the area of rhythm. Although the mean score for the rhythm area on the listening posttest was a respectable 87 percent, this area showed the least gain of the three. Least gain in this area, and in the entire test, was the meter recognition. Perhaps more items in this area, or easier items, might have produced a different result. This part of the program will be reviewed.

It is interesting to note that the area of phrasing which had the lowest pretest mean (56%), had the greatest gain and the highest posttest mean (98%). This may indicate that the area of phrasing is more foreign to students of this age and proficiency level. Once shown the elements of good phrasing, they readily progressed.

On-line Program Data

Two types of records are available in CAI: course-oriented records, sorted by item which facilitates course revision; and student-oriented records, sorted for analysis of student progress. Student-oriented records were selected for analysis of on-line data, in the present study. The records are printed out from magnetic tapes which record all student responses. A sample of student records is shown in Table 11 (see Appendix).

Student responses, which numbered several thousand, were manually extracted from student records and charted so the individual items could be examined vertically and the student's progress followed horizontally. Table 12 (see Appendix) shows an example from this chart. The numbers represent the incorrect responses made in each frame. The slashes (/) show the number of times a student chose to listen again to the music before responding to the question.

Table 13 (see Appendix) shows data tabulated from student records. The percent of correct responses reflects the number of times the student responded correctly on the first attempt.

Neither the percent of correct responses nor the number of errors shown include the remedial branches since number of branches varied among students. The data represent only responses for the parts of the program taken by all students.

Individualization in the program may best be seen by the number of remedial branches taken by each student. This number ranged from three to twelve. A student was branched into a remedial section when he failed to meet the criterion level on the preceding program segment.

Table 13 also shows the total time needed by each student to complete the on-line program. The mean time was approximately 4 1/2 hours (or 9 half-hour sessions).

Tables 14, 15, and 16 (see Appendix) show the rank order of students for percent correct on-line, number of errors on-line, and time for completing the program. There was a greater range in the number of errors among students than there was in the correct responses since it was possible to have more than one error in one frame.

Finally, Table 17 represents a master composite by student. Student B who took the most branches and required the most time to complete the course scored slightly below the criterion level on both listening and performance tests. Student A, however, who required the second highest number of branches and total time finished above the criterion level on both tests; in fact, this student scored 99 percent on the performance posttest, a gain of 86 percent. The four students scoring 100 percent on the listening posttest ranged in remedial branches from four to eight. These four top students all were well above the criterion level on the performance test also.

CHAPTER IV

SUMMARY

The purpose of the present study was to extend the applicability of a combined CAI and related off-line practice program developed in USOE Project 7-0760 and evaluate its effectiveness through the development and implementation of criterion-referenced measures.

An existing CAI instrumental musicianship course, stressing aural concepts of articulation, phrasing, and rhythm, was modified as the audio models were extended from clarinet only to flute, clarinet, saxophone, trumpet, and horn models. Considerable revision was also done on the related off-line practice program which formerly had been designed for clarinet only. The course previously taken by clarinet students only is now considered applicable to all treble clef wind instruments and was tested in the present study by twenty-five intermediate level students of flute, clarinet, saxophone, oboe, trumpet, and treble clef baritone.

At the end of the original project the course was extensively revised; it was completely reviewed and debugged, i.e., checked for programing errors, at the outset of the present study. Image reels were rephotographed and duplicated for the larger sample.

Criterion-referenced measures were developed to reflect the program objectives, piloted, revised, and administered as pre- and posttests. Group gains in both areas of listening and performance were statistically significant with $p < .001$. All but three of the twenty-five subjects attained the criterion level of 85 percent correct on the listening posttest and these three were close with scores of 81 percent.

All but three of the twenty-five subjects attained a score of more than 90 percent correct on the performance posttest. Half of the sample had scores of 97 percent or higher.

The rationale behind the study -- that aural concepts in musicianship are related to performance -- was borne out by a correlation coefficient of .59, statistically significant with $p < .002$.

Greatest gains were made in the area of phrasing, probably more foreign to students of this level than rhythm or articulation. Once shown the basic elements of good phrasing the students made remarkable gains. The meter aural identification part of the rhythm program apparently was the least effective part of the entire program. It is possible that easier test items might have produced different results; however, this part of the program shall be reviewed.

Although the design was a one-group pre-post design, the results have credibility. Subjects continued their band activities during the approximate six-week program but such dramatic spurts in scores could hardly be attributed to this "rival hypothesis" since these students had been playing instruments for approximately five years or more.

It is hoped that this program and others designed for young students could be made more accessible via instructional terminals in the schools or mobile vans.

REFERENCES

Deihl, N. C., and Radocy, R. E. Development and evaluation of computer-assisted instruction in instrumental music. Report No. R-24, University Park: The Pennsylvania State University, September 1969, ERIC No. ED 035 314.

Deihl, N. C., and Radocy, R. E. Teaching musicianship via CAI. Educational Technology Magazine, XI, August 1971, 23-24.

APPENDIX A

Tables

Table 9

Scores by Item on Performance Test with Mean Gains by Area

	Phrasing				Articulation				Rhythm				Integrated					
	Item 1		Item 2		Item 3		Item 4		Item 5		Item 6		Item 7		Item 8		Item 9	
Student	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
A	0%	100%	8%	100%	0%	100%	25%	100%	0%	100%	25%	100%	8%	100%	38%	100%	13%	94%
B	13	63	0	92	100	100	25	88	100	50	100	100	25	75	50	69	50	75
C	63	100	83	100	100	100	100	100	38	88	100	100	42	92	69	100	100	100
D	0	88	25	100	0	100	0	100	100	100	100	100	0	92	0	81	56	100
E	13	63	0	100	10	100	63	63	100	100	100	100	33	58	25	69	63	59
F	38	88	75	100	0	100	0	100	38	100	50	100	75	92	38	94	63	100
G	38	88	17	92	50	100	50	63	25	100	100	100	33	100	25	88	50	100
H	50	100	42	92	13	100	13	100	0	100	100	100	33	100	94	100	31	100
I	25	88	0	100	13	100	25	100	0	100	100	88	25	100	13	94	50	100
J	38	75	8	100	50	100	0	100	100	100	38	100	8	100	81	100	6	100
K	38	88	25	92	100	100	25	100	0	100	88	100	42	92	75	100	100	100
L	75	75	67	100	100	100	13	100	100	100	63	100	50	92	100	100	63	100
M	0	100	8	100	38	100	0	100	100	50	38	100	0	83	13	88	31	100
N	100	88	25	100	63	100	13	100	50	100	63	100	83	100	31	100	100	100
O	38	100	25	92	0	50	38	100	13	88	50	100	0	100	6	94	38	94
P	0	100	0	100	13	100	88	100	0	100	25	100	25	83	25	88	25	100
Q	38	88	0	100	13	100	50	100	0	100	100	100	33	100	13	100	56	100
R	38	88	16	50	100	100	0	100	88	100	100	100	42	83	13	94	100	100

Table 9 (Continued)

	Phrasing				Articulation				Rhythm				Integrated					
	Item 1		Item 2		Item 3		Item 4		Item 5		Item 6		Item 7		Item 8		Item 9	
Student	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
S	38%	88%	8%	100%	13%	100%	0%	88%	100%	100%	0%	100%	0%	100%	75%	100%	0%	100%
T	50	100	42	100	0	100	38	100	13	100	50	100	50	100	50	88	19	100
U	13	100	0	92	0	100	38	100	0	100	38	100	33	92	56	94	0	56
V	13	50	8	100	0	100	0	100	100	0	100	100	0	100	0	94	0	100
W	0	100	0	100	100	100	0	100	100	100	100	100	33	92	50	88	50	100
X	38	75	25	100	38	100	0	100	50	100	0	100	8	83	38	100	19	100
Y	25	100	8	75	25	100	38	75	100	100	100	100	25	100	50	94	0	100
Means	31%	88%	20%	95%	34%	98%	26%	95%	53%	91%	69%	98%	28%	92%	41%	93%	43%	95%
Mean Gains	57%		75%		64%		69%		38%		29%		64%		52%		52%	

Table 10

Comparison of Student
Listening and Performance Scores

Student	Listening Pretest	Listening Posttest	Performance Pretest	Performance Posttest
A	34%	89%	13%	99%
B	50	81	51	79
C	77	89	77	98
D	58	92	31	96
E	62	96	44	80
F	58	100	42	97
G	65	81	43	92
H	81	100	42	99
I	65	81	28	97
J	69	89	37	97
K	65	89	55	97
L	89	100	70	91
M	65	100	25	91
N	81	100	59	99
O	62	92	23	91
P	54	85	22	97
Q	65	89	34	99
R	73	92	55	91
S	48	100	26	97
T	65	96	35	99
U	31	85	20	93
V	62	96	24	83
W	37	85	48	98
X	65	96	24	95
Y	69	96	41	94
Means	62%	92%	38.8%	94%
Mean Gains	30.0%		55.2%	

Table 11

CAI Student-Oriented Records for Five Frames

Student Number	Frame Identifier	Response Latency	Response Identifier	Date	Time of Day	Frequency of Attempts
XAD	QU57E	2.7	CC	4/17/72	15:42.10	1
RESPONSE - ROW 08 COL 21						
XAD	QU57F	2.2	LA	4/17/72	15:42.37	1
RESPONSE - ROW 12 COL 21						
XAD	QU57F	3.5	WA	4/17/72	15:42.64	2
RESPONSE - ROW 08 COL 05						
XAD	QU57FX	4.0	GO	4/17/72	15:44.40	1
RESPONSE - ROW 13 COL 21						
XAD	QU57G	2.1	LA	4/17/72	15:44.80	1
RESPONSE - ROW 12 COL 21						
XAD	QU57G	1.5	WA	4/17/72	15:45.9	2
RESPONSE - ROW 08 COL 05						
XAD	QU57H	2.0	CC	4/17/72	15:45.67	1
RESPONSE - ROW 08 COL 05						

Legend for Table 11

XAD identifies the student responding.

QU57E identifies the question to which the student is responding.

The number following shows the time or response "latency" in seconds.

Next is a two-character identifier assigned in the program to a particular lighted area or set of coordinates on the CRT:

CC means correct answer chosen.

LA indicates the student elected to listen again to the example.

WA represents "articulation," in this case a wrong response.

GO indicates the student elected to go on to the next question rather than hear further examples.

The date, expressed in a month-day-year format.

The exact time of the student task expressed in hours, minutes, and hundredths of a minute.

The final digit indicates the cumulative number of attempts the student made on this particular question.

RESPONSE row and column indicates the CRT coordinates (where the light pen touches the CRT) for the response.

Table 12

Extract From Student Response Chart

Student Number	Instructional Frames						Remedial Frames		
	166	167	168	169	171	172	174	175	176
A	1	1	0	0	1	1/	Ø	0	0
B	1	0	0	0	Ø	0			
C	0	0	0	0	Ø	0			
D	0	0	0	0	Ø	0			
E	0	0	0	0	0	1			
F	0	0	Ø	0	Ø	1			
G	0	0	Ø/	0	Ø	0			
H	2	0	0	Ø	Ø	Ø			
I	1/	0	Ø	0	1/	0			
J	0	0	0	0	1/	1	Ø	Ø	0
K	0	Ø	0	1	1/	0	1/	Ø	Ø
L	1	0	0	0	Ø	0			
M	0	0	0	0	Ø	0			
N	0	0	0	0	1/	0			
O	0	0	0	0	1/	1	Ø	0	0
P	0	0	0	0	1	1	1/	1/	0
Q	0	0	0	0	Ø/	1			
R	1	0	0	0	Ø	1/			
S	0	0	0	0	Ø	1			
T	0	1	Ø	0	Ø	1/	1	1/	1/
U	1	0	0	0	1	0			
V	0	0	0	0	Ø	0			
W	0	0	0	0	1/	0			
X	1	1	0	0	0	0			
Y	0	0	0	0	Ø	0			

0 = No Errors
1 = One Error
2 = Two Errors
/ = Listened Again

Table 13

On-line Student Records

Student	Percent of Correct Responses Excluding Remedial Branches	Number of Errors	Branches Taken	Total Time to Complete Program
A	65.38%	78	10	5 hrs. 13 min.
B	67.03	92	12	5 30
C	77.47	54	8	4 20
D	79.67	47	5	3 33
E	75.27	51	6	4 42
F	77.47	48	8	4 17
G	89.67	50	6	4 37
H	86.26	32	4	4 59
I	73.63	62	9	4 9
J	81.87	39	6	4 20
K	80.22	40	6	3 30
L	85.16	41	5	4 19
M	80.77	44	4	4 49
M	85.71	37	4	4 6
O	80.77	42	5	3 33
P	82.42	42	5	3 42
Q	79.12	45	5	4 4
R	83.52	30	3	4 27
S	74.73	61	8	4 12
T	80.77	44	5	3 44
U	64.84	80	9	5 6
V	75.82	48	3	4 3
W	76.92	53	7	3 55
X	77.47	54	7	4 18
Y	80.22	51	5	4 8
Means	70.09%	50.6	6.2	4 hrs. 18 min.

Table 14

Rank Order of Percent Correct On-line

Student	Rank	Percent Correct
H	1	86.26%
N	2	85.71
L	3	85.16
R	4	83.52
P	5	82.42
J	6	81.87
M	8	80.77
O	8	80.77
T	8	80.77
K	10.5	80.22
Y	10.5	80.22
D	12.5	79.67
G	12.5	79.67
Q	14	79.12
C	16	77.47
F	16	77.47
X	16	77.47
W	18	76.92
V	19	75.82
E	20	75.27
S	21	74.73
I	22	73.63
B	23	67.03
A	24	65.38
U	25	64.84

Table 15

Rank Order of Number of Errors On-line

Student	Rank	Errors
R	1	30
H	2	32
N	3	37
J	4	39
K	5	40
L	6	41
O	7.5	42
P	7.5	42
M	9.5	44
T	9.5	44
Q	11	45
D	12	47
F	13.5	48
V	13.5	48
G	15	50
E	16.5	51
Y	16.5	51
W	18	53
C	19.5	54
X	19.5	54
S	21	61
I	22	62
A	23	78
U	24	80
B	25	92

Table 16

Rank Order of Time On-line

Student	Rank	Time
K	1	3 hrs. 30 min.
D	2.5	3 33
O	2.5	3 33
P	4	3 42
T	5	3 44
W	6	3 55
V	7	4 3
Q	8	4 4
N	9	4 6
Y	10	4 8
I	11	4 9
S	12	4 12
F	13	4 17
X	14	4 18
L	15	4 19
C	16.5	4 20
J	16.5	4 20
R	18	4 27
G	19	4 37
E	20	4 42
M	21	4 49
H	22	4 59
U	23	5 6
A	24	5 13
B	25	5 33

Table 17

Master Composite by Student

Student	Pretest Listening	Posttest Listening	Pretest Performance	Posttest Performance	Percent Correct On-line	No. of Remedial On-line	Branches	Total Time On-line
A	34%	89%	13%	99%	65.38	78	10	5:13
B	50	81	51	79	67.03	92	12	5:33
C	77	89	77	98	77.47	54	8	4:20
D	58	92	31	96	79.67	47	5	3:33
E	62	96	44	80	75.27	51	6	4:42
F	58	100	42	97	77.47	48	8	4:17
G	65	81	43	92	79.67	50	6	4:37
H	81	100	42	99	86.26	32	4	4:59
I	65	81	28	97	73.63	62	9	4:9
J	69	89	37	97	81.87	39	6	4:20
K	65	89	55	97	80.22	40	6	3:30
L	89	100	70	91	85.16	41	5	4:19
M	65	100	25	91	80.77	44	4	4:49
N	81	100	59	99	85.71	37	4	4:6
O	62	92	23	91	80.77	42	5	3:33
P	54	85	22	97	82.42	42	5	3:42
Q	65	89	34	99	79.12	45	5	4:4
R	73	92	55	91	83.52	30	3	4:27
S	48	100	26	97	74.73	61	8	4:12
T	65	96	35	99	80.77	44	5	3:44
U	31	85	20	93	64.84	80	9	5:6
V	62	96	24	83	75.82	48	3	4:3
W	37	85	48	98	76.92	53	7	3:55
X	65	96	24	95	77.47	54	7	4:18
Y	69	96	41	94	80.22	51	5	4:8
Means	62.0%	92.0%	38.8%	94.0%	78.09%	50.6	6.2	4:18

Pre- Post Mean Gains Listening = 30.0% Performance = 55.2%

APPENDIX B

Pictures

Picture Below: Investigator Observing On-line Instructional Session

Picture Below: Programer Revising Course Material at the Instructional Station

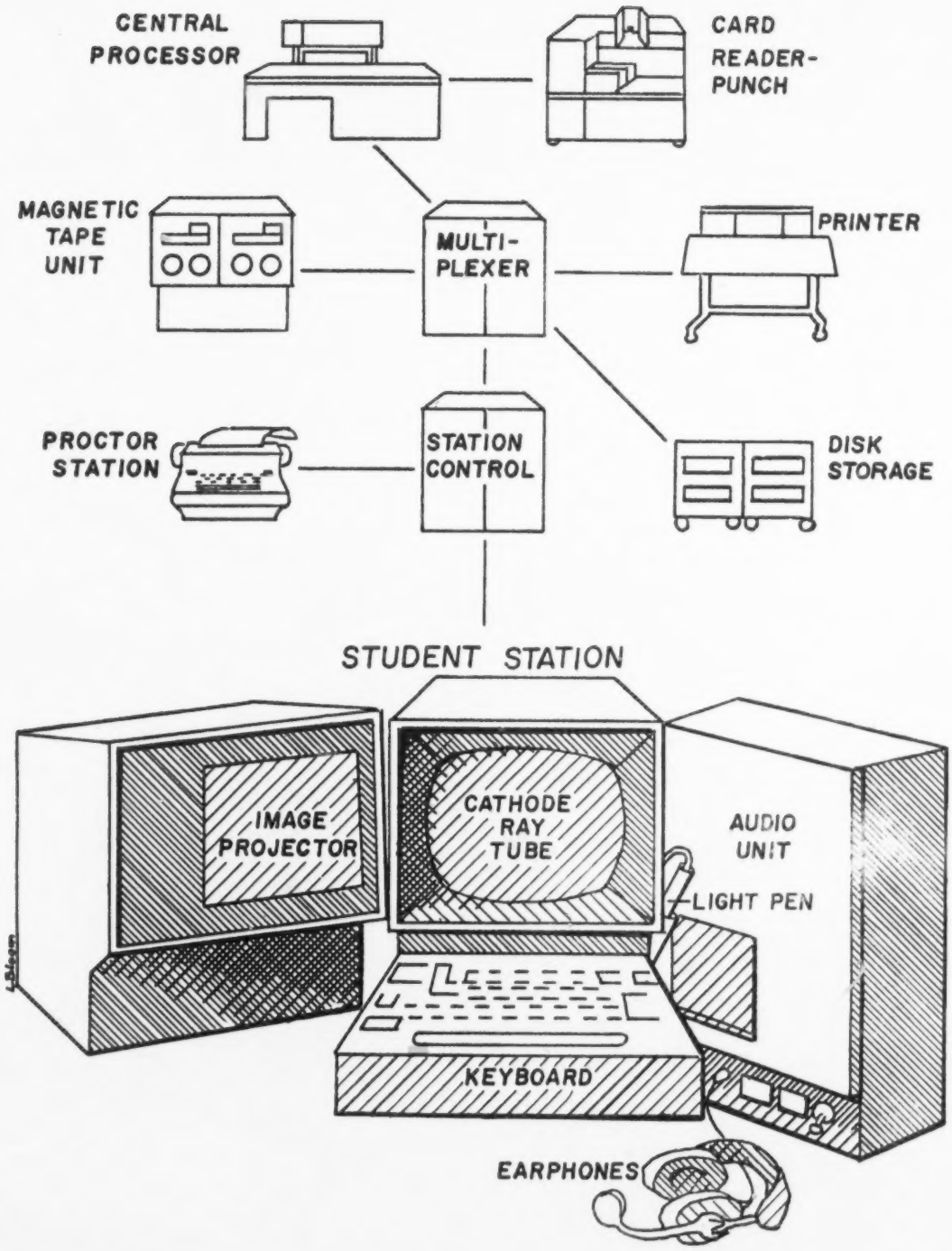

Illustration of the Instructional Terminal and System Components of the IBM 1500 Instructional System.